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Annual bioenergy crops for biofuels production: Farmers' contractual preferences for producing sweet sorghum

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ABSTRACT

Dedicated annual sorghum crops, such as sweet sorghum or energy sorghum, may provide an option for farmers to supply cellulosic feedstocks for biofuel production and help the industry meet government mandates. Kansas farmers are poised to be major producers of sweet sorghum for biofuels due to favorable agro-ecological conditions. The purpose of this paper is to assess Kansas farmers' willingness to grow sweet sorghum under contract as a feedstock for biofuel production. The paper examines farmers' willingness-to-pay for contract attributes and the impact of socio-economic factors on their willingness-to-pay for these attributes. A stated choice survey was administered to Kansas farmers to assess their willingness to grow sweet sorghum for biofuels under various contracting scenarios. Results show that farmers may be willing to grow biomass for bioenergy under contract, but may have varying preferences for the importance of contract attributes such as net returns, contract length, insurance availability, government incentives, and potential for biorefinery harvest options based on socio-economic characteristics of growers.

1. Introduction

The Energy Independence and Security Act of 2007 states, in part, that biofuel production must increase to 36 billion gallons by the year 2022, of which 21 billion gallons must come from "advanced" or second-generation biofuel feedstocks, which includes dedicated annual bioenergy crops [1]. To date, cellulosic biofuel production has significantly fallen short of set goals and mandates due to economic feasibility concerns, market development issues, and uncertainties about government policy [2–4]. Among important pre-conditions for meeting set goals is the agricultural producers' willingness to grow biomass crops. While the literature in this area has grown over the last decade, many important questions still remain about appropriate incentive mechanisms and viability of alternative bioenergy crop varieties [5].

Dedicated annual bioenergy crops provide a potentially viable biofuel feedstock enterprise option for farmers. They can serve as a flexible alternative cash crop for farmers that can be grown in traditional crop rotations. For example, sweet, energy or forage sorghum varieties may serve as annual bioenergy crops. There are several advantages to these types of sorghum crops, including production of high amounts of biomass, drought tolerance and the ability to incorporate them into existing crop rotations [6]. This study focuses on the use of sweet sorghum specifically, though forage and energy varieties of sorghum would be viable substitutes. Management of sweet sorghum is similar to grain and forage sorghum under dryland conditions. Propheter et al. [7] found favorable yields for different sorghum varieties in the less than ideal growing conditions in Kansas. They also found that these annual crops produced more usable biomass than perennial options during the study period, which increases appeal of crops such as sweet sorghum for biofuels in the Great Plains of the United States.

To ensure the viability of biofuel production from cellulosic feedstocks, it is important to know under which conditions farm managers will be willing to produce cellulosic biofuel feedstocks. Farmers are more likely to supply cellulosic biofuel feedstocks if the expected payoff from the enterprise is greater than any other possible land use [8]. However, Rajagopal and Zilberman [5] indicate that the factors that lead to farmers' adoption of biofuel technologies are still not well understood. Among such factors is the coordination of transactions at the producer-processor

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interface of the cellulosic biofuel supply chain, specifically the nature of contractual arrangements.

Contract theory and transaction cost literature delineates various strategies for coordinating transactions along the supply chain. These strategies form a vertical coordination continuum ranging from simple spot market transactions to complete vertical integration [9]. Empirical studies have identified a variety of coordination strategies including contracts and equity arrangements and have shown that when transactions involve high levels of risk and uncertainty, strategies with higher levels of vertical integration are preferred [10–12]. Specification contracting is one such strategy that involves establishment of legally enforceable conditions of exchange. With appropriate specifications, contractual arrangements can reduce the uncertainty associated with price and revenue for producers, while allowing processors to gain more influence over coordination without all the risk and rigidity associated with equity-based arrangements.

The fact that the markets for cellulosic biofuel feedstock are still underdeveloped or nonexistent creates an extra level of risk and uncertainty for farmers in addition to traditional weather and price uncertainty. Under these conditions, vertical coordination through specification contracts between growers of cellulosic biofuel crops (e.g. sweet sorghum) and ethanol producers can represent a potential solution. The question then becomes, what transaction attributes should be specified in such contracts. Based on contract literature and empirical studies of various agricultural commodity markets, contractual arrangements between growers and processors are likely to be affected by multitude of factors, including contract pricing, timeframe, acreage commitments, risk, timing of harvest, yield variability, feedstock quality, harvest responsibilities (e.g. custom harvesting), nutrient replacement, location of biorefineries, available cropping choices, technology, and conservation considerations [13–18].

The purpose of this study is to examine farmers' willingness to produce sweet sorghum under alternative contractual, pricing, and harvesting arrangements in Kansas. Assessment of farmers' willingness to adopt a sweet sorghum enterprise under different contractual arrangements is implemented using an enumerated field survey with stated choice techniques. The survey examines farmers' willingness-to-pay for different contract attributes and how alternative socio-economic and farm factors may impact their contractual preferences. A stated choice approach following Louviere et al. [19] is used to assess farmers' willingness to adopt. Survey results are analyzed using a random parameters conditional logistic regression model [20,21]. A unique contribution of this paper is the estimation of marginal effects of socio-economic and farm characteristics on the willingness-to-pay for specific contract attributes. The paper extends the literature on biomass contracting by providing empirical insights into the importance of key contract attributes for supplying dedicated annual bioenergy crops given the specific socio-economic characteristics of growers.

The rest of the paper is organized as follows, section two provides some needed background on prior literature. Section three presents the description of survey method and data, as well as the details of the stated choice experiment. The empirical model and the estimation methods are presented in section four, followed by the results and concluding remarks in sections five and six.

2. Biofuel feedstock contracting and adoption

A large amount of research exists on the technical feasibility of growing cellulosic biofuels (including biomass yield and production potential), as well as farmgate and breakeven pricing (e.g. Refs. [22–33]). However, these studies do not evaluate farmer' willingness to grow a dedicated bioenergy feedstock. In addition, this research does not identify the characteristics of farmers that would provide that feedstock. While these studies provide a large amount of useful information and insight, they may be of little relevance if farmers are not willing to grow bioenergy crops for biofuel production.

A small number of studies has examined farmers' willingness to grow bioenergy crops, especially under contract. Hipple and Duffy [34] used personal interviews to examine farmers' willingness to grow switchgrass in Iowa. Factors impacting willingness to grow included profitability, return on investment, complexity, and economic sustainability. Quality of life issues were also considered important, including compatibility with personal and family values and beliefs, health and safety, environmental, and aesthetic issues.

Jensen et al. [35] assessed Tennessee farmers' willingness to grow switchgrass on their land. They found that average higher net farm income per acre decreased the likelihood of growing switchgrass, as the opportunity cost of converting land may be too high. In addition, they found that the requirement of signing a long-term contract would likely decrease the likelihood of planting switchgrass.

Sherrington et al. [36] examined farmers' willingness to grow dedicated perennial bioenergy crops in the United Kingdom. They found that factors impacting farmers' willingness to grow using focus groups included: potential financial returns and competition with other potential land uses; uncertainty about the financial viability of growing bioenergy crops and markets; the requirement for financial incentives to grow dedicated bioenergy crops due to high establishment costs; need for contracts due to limited markets; and environmental impacts.

Paulrud and Laitila [37] examined farmers' willingness to grow dedicated perennial bioenergy crops (e.g. willow and canary grass) in Sweden. They utilized a stated choice experiment for a generic dedicated perennial bioenergy crop. The authors find that farmers are willing to accept less net returns if the crop can be grown under contract; a farmer would require higher returns from the crop the longer the rotational period; government subsidies for growing a dedicated perennial bioenergy crop have no direct impact on farmer's willingness to grow the crop; and net income from crop production increased the likelihood of planting a dedicated perennial bioenergy crop.

Qualls et al. [38] examined farmers' willingness to grow switchgrass in 12 southeastern U.S. states. Of interest, was the result that as the price per unit of switchgrass increased, the amount of land a farmer was willing to plant to switchgrass increased. In addition, they found that prior experience with producing a commodity under contract reduced farmers' interests if they were willing to covert land to switchgrass production.

Altman et al. [39] examine farmers' willingness to harvest alternative sources of crop residues (e.g. corn stover and wheat straw) and hay in Illinois and Missouri. They find that supply for all the feedstocks is highly elastic (ranging from 2 to 10, depending on the feedstock and location). That is, as the price of a feedstock increases, farmers' willingness to supply that feedstock increases greater than the percentage increase in price. Thus, price plays a significant factor in farmers' willingness to harvest crop residues and hay as a bioenergy feedstock.

Alexander et al. [40] indicate that contract length will be particularly important for contracts for growing dedicated annual bioenergy crops. These crops do not have a long establishment period like dedicated perennial bioenergy crops and they can fit into traditional cropping systems, only requiring a short-term commitment by the farmer. Longer term contracts for these types of crops may reduce the flexibility that dedicated annual bioenergy crops can provide. In addition, refineries will have to still take storage and transportation issues into consideration when

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